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Climate Ribbon™, Brickell City Center Miami, Job Report

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Abstract

In the new Brickell City Center the public spaces between the retail shops are covered by an open steel glass structure. The primary structure consists of triangular surfaces which are inclined towards each other. Below this transparent rain protection the 3-dimensional shaped "Blades", PTFE-covered continuous stripes, are arranged for sun shading. Eight of the in section triangular shaped "Blades" and two "Delta Beams" along the border vary in their dimensions and orientation to ensure the sun shading task in each position. One of the challenges aside extremely high wind loads was the almost invisible membrane fixation. The total length of the Climate Ribbon™ is over 200m.

Peer-review under responsibility of the TensiNet Association and the Cost Action TU1303, Vrije Universiteit Brussel

Keywords: PTFE Glass Membrane; rain protection; shading roof; air flow; patterning

1. Introduction

The Climate Ribbon™ is part of the new Brickell City Center located downtown Brickell - Miami. Brickell is known as the financial district of Miami and like other quarters it is currently in an expansion phase with many new construction sites. The whole Brickell City Center project has a volume of about 1.05 Billion US$. It is placed on an area of about 37000 square meters and contains about 5 million square meters of office, residential, hotel, retail and entertainment spaces. The project was developed by Swire Properties Inc. The site was started in 2012.

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2. Description

The function of the Climate Ribbon™ is to protect the open space between the retail shops from the almost tropical rain, as well as from Florida's sun. Furthermore the shape of the membrane covered elements, the so called blades, should conduct the fresh wind from the Biscayne Bay through the public spaces of the center to achieve a comfortable climate without air conditioning in these areas.

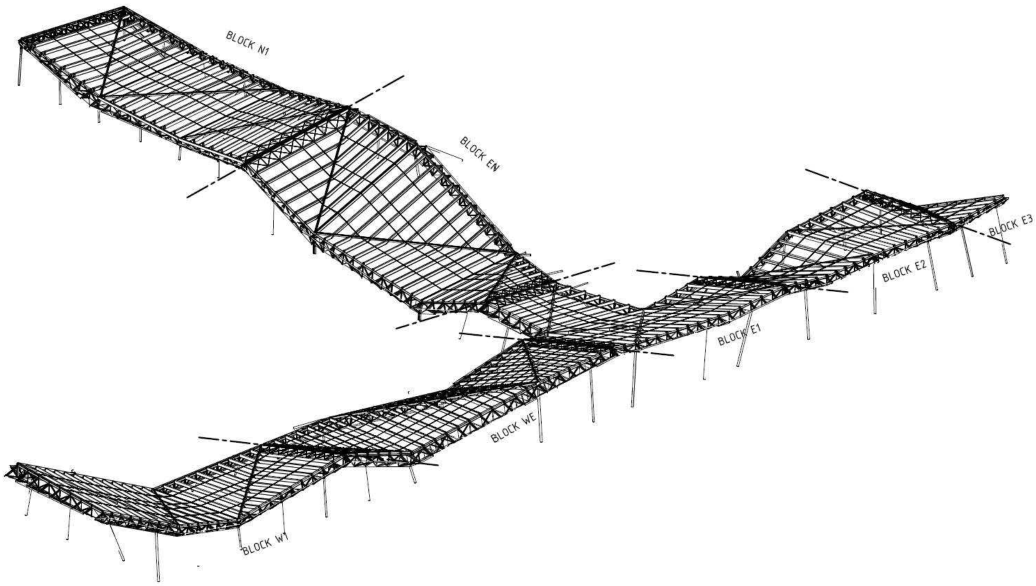

Fig. 1. Isometric View

The Climate Ribbon™ is placed directly on top of public walkways. The width is constant about 20 m and the glass covered surface follows a facetted triangular shape.

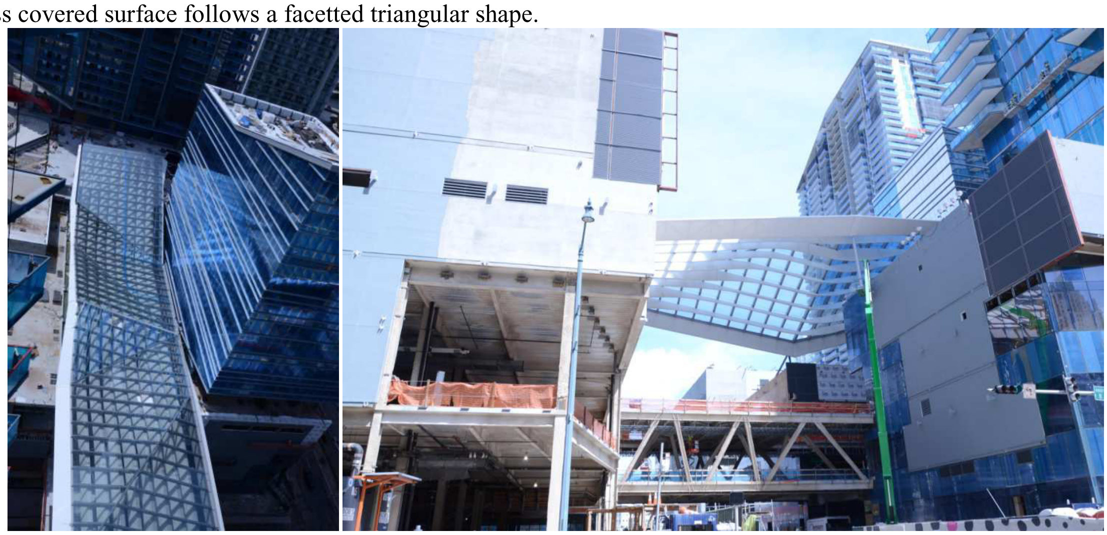

Fig. 2. (a) Inclined glass planes, (b) Road crossing

The lateral borders are formed by triangular truss girders. Columns standing on the main building structure carry these border beams. Box beams span between the tri-chord trusses over a length of 20 m and carry the roof. The lateral truss is cladded with membrane and forms the so called Delta Beam. Under the box beams 8 rows the so called blades, membrane cladded lamellas are hung and run continuously.

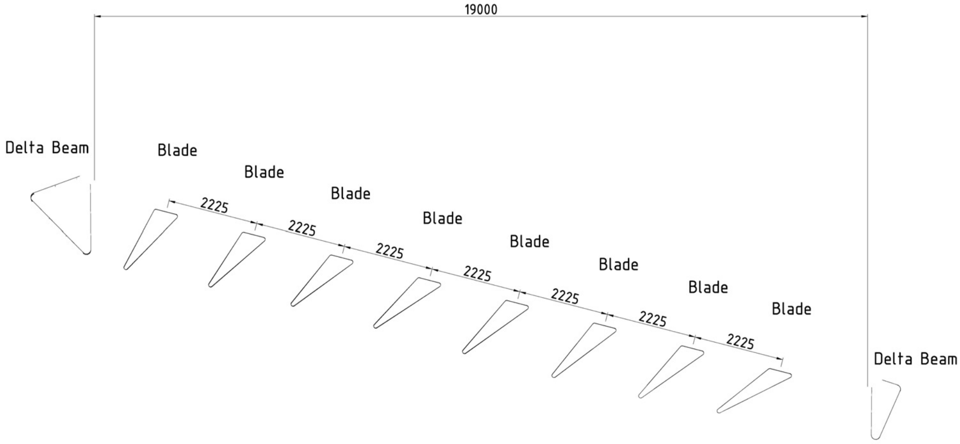

Fig. 3. section trough Delta Beams and Blades

3. Geometry

The architects Hugh Dutton Associés (HDA) have defined the shape and inclination of the Blades. Several studies concerning the incidence of sunlight over the year and the wind flow from Biscayne Bay resulted in the shape, length and inclination of the Blades. Also the lateral Delta Beams are involved in the function of the Climate Ribbon. The substructure of each Blade, a tri chord girder, has an exact shape which had to be strictly followed. The girder's function is to define the shape the membrane, but due to the high wind load in Miami the blades have to withstand also quite high external loads.

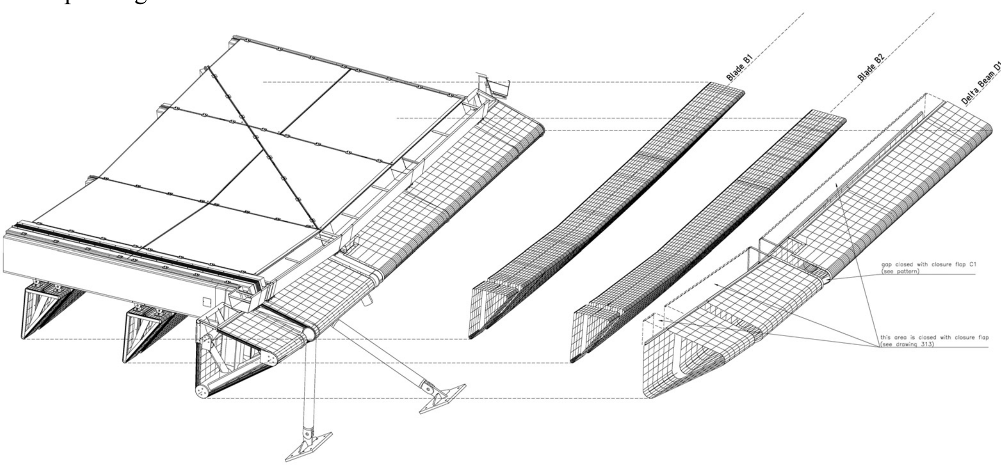

Fig. 4. Cout out trough Delta Beams and Blades

4. Analysis

In wind tunnel tests a gust wind speed of almost 300 km/h has been determined, which results in up to 135 psf wind load, which is about 6.5 kN/m². The blade structure has been dimensioned to carry these wind loads. According to the different wind load areas over the project, and the individual span of each blade the steel substructure has been determined.

Due to the high stiffness of the PTFE-glass membrane and the high wind load, especially in short blades which did not allow for much deformation, quite high membrane stresses occur.

The stresses exceeded the nominal strength of the chosen PTFE glass material 18039. But material certificates showed that the real strength of this material is much higher, so that the material could safely be used.

The use of a stronger product would have resulted in even higher membrane stresses, due to the higher stiffness of the material. This would have led in increased steel dimensions and have caused additional problems to the detailing and to the patterning.

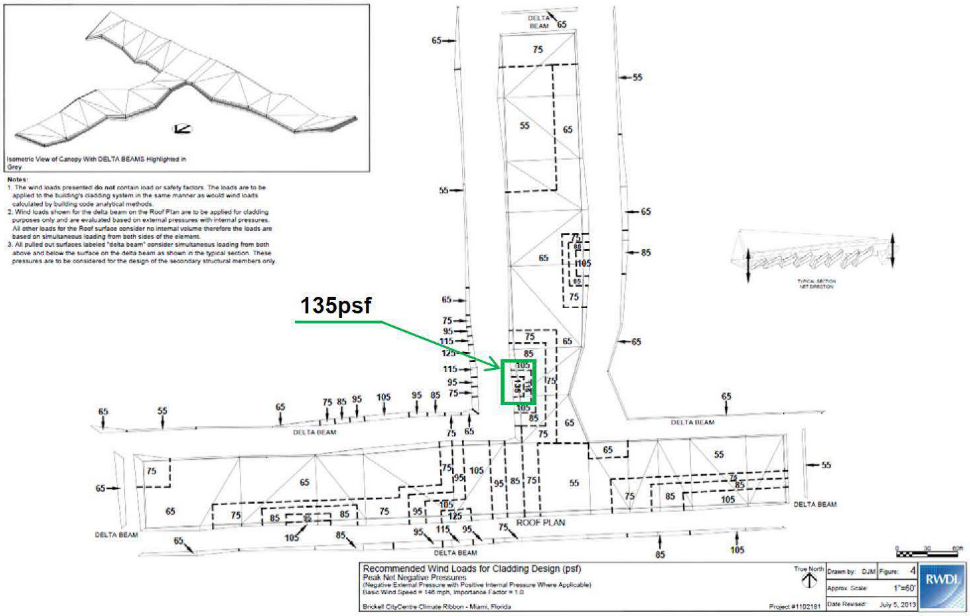

Fig. 5. Wind Load distribution

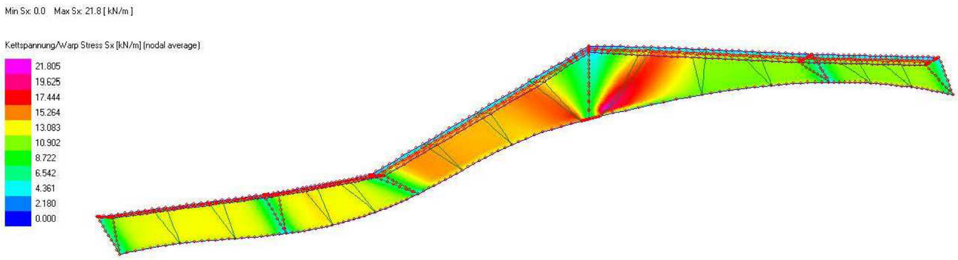

Fig. 6. Membrane stress in the principle direction

5. Details

The workshop design for all the 313 Blades and 77 Delta Beam elements was a challenge. All aluminum clamps had to be invisible. The clamping around the Blades was placed at the top, directly under the glass roof and the steel structure.

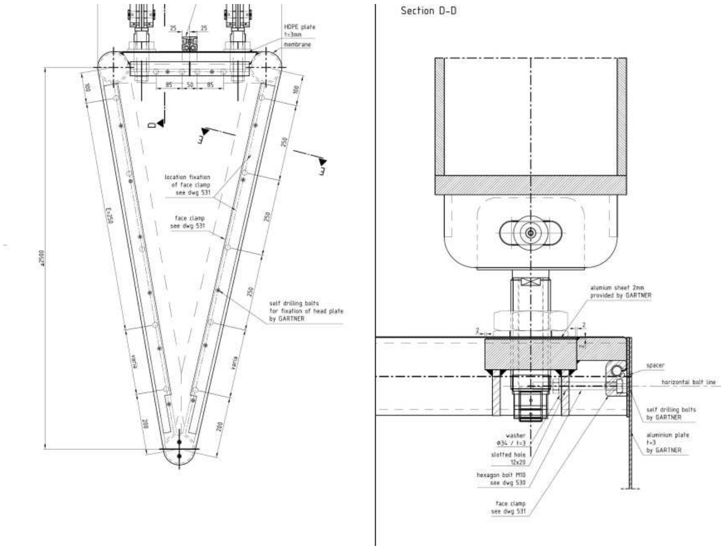

Fig. 7. Blade detailing

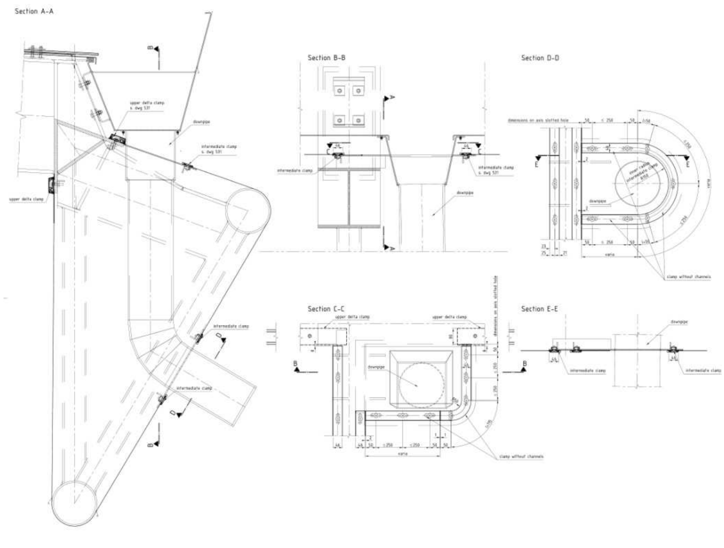

Fig. 8. Delta Beam Detailing

It was defined, that the Clamps have to be closed after final installation to get a watertight covering around the Blades. It was not allowed to keep a gap to adjust tolerances caused by the steel manufacturing. So the clamps could be used just for tensioning, but not to compensate tolerances.

At the end of each Blade the clamping had to be invisible so that in the final state the wrapping of all single Blades run continuously. The typical joints have a defined gap of 20mm between the Blades. At the expansion joints of the building the blades have got a gap of 200 mm.

The membrane had to be reverted around the end-steel profile and clamped to the back side. Even here in this position the possibilities to tension and especially to adjust were rather small.

The main details followed all this principle, but with different geometries. Project specific software routines have been developed to generate the workshop drawings for the clamping bars including all holes, angels and cut outs automatically from the system-line files.

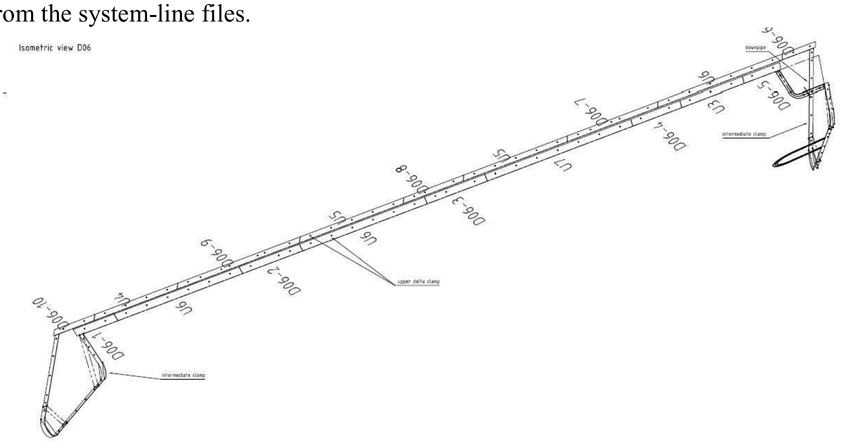

Fig. 9. Automatic Clamping generation for the Delta Beam

6. Pattering

A routine has also been used to generate automatically the standard pattern along the Blades and Delta Beams. A special challenge have been the so called L-Blades. They turn from one Climate Ribbon-line to the perpendicular one. The extreme shape of the L-Blades was made with the initial shape defined by the architect, and a very smooth formfinding process in order to find the best matching equilibrium shape.

To achieve a homogeneous shape free of wrinkles, the number of necessary seams was very high. One L-Blade has up to 60 pattern.

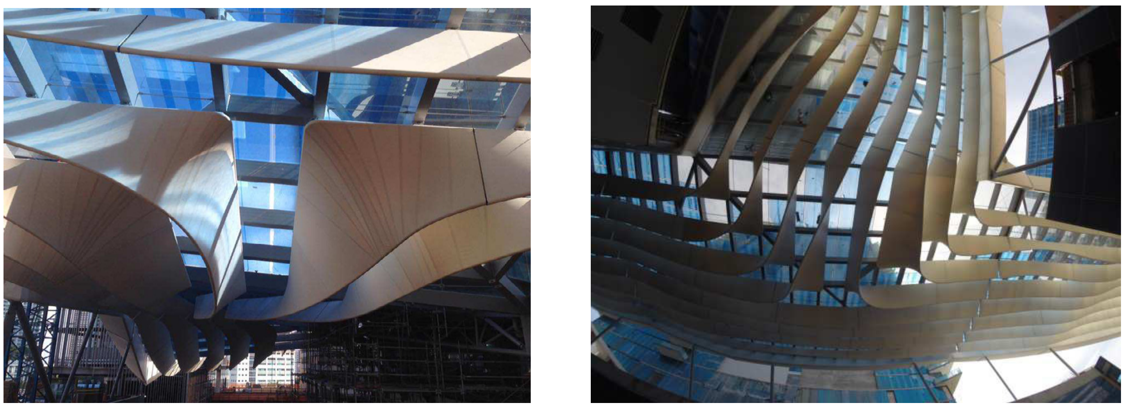

Fig. 10. (a) and (b) Final appearance of the L-blades

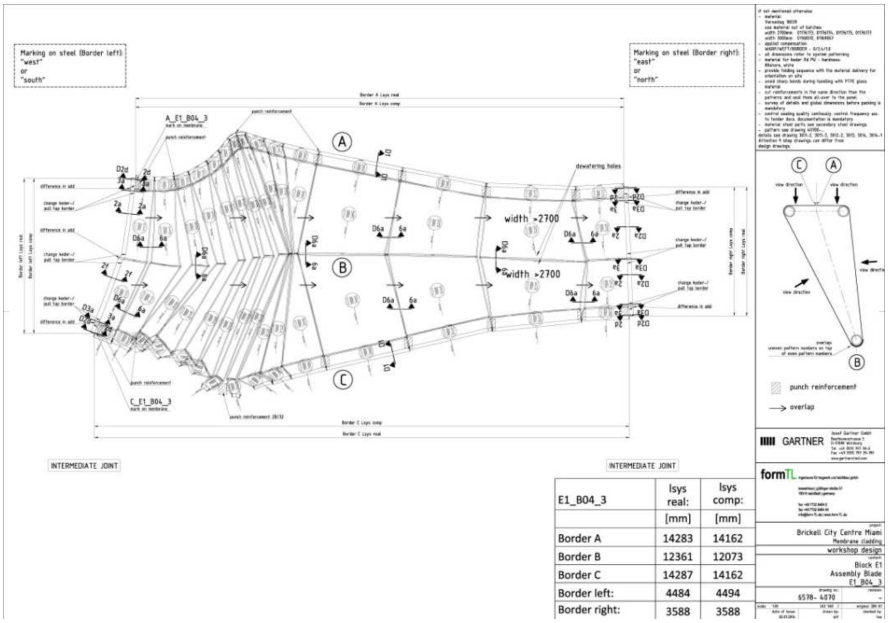

Fig. 11. Seam Layout of the L-blades

7. Fabrication and Installation

To get the design prestress in the membrane, the compensation has to be defined and chosen correctly. Biaxial tests have been made from almost all rolls of fabric. The pattern have been assigned to the corresponding material.

7.1. Blades

The Blades were Pre installed and wrapped in a warehouse in Miami. The covered Blades were then transported on site and lifted up in the final position.

As the size of the L-Blades did not allow a transport after the installation, they were wrapped directly on site, on the floor underneath their final position.

Fig. 12. (a) Blade steel structure (b) Blade wrapping in the warehouse

7.2. Delta Beam

As the steel structure within the Delta-Beam is part of the roof's primary structure, the membrane panels had to be installed on site in the final position. The membrane has to cover the substructure completely, so that there was no possibility to place nuts from inside.

To avoid problems due to tolerances, slotted holes are provided and bolts with special designed anchor nuts were placed and fixed from outside.

The Delta Beam membrane has also a high detailing rate. Several spaces for downpipes and strut-connections had to be included.

In the position of the road-crossing the length of a single Delta-Beam element was up to 28m

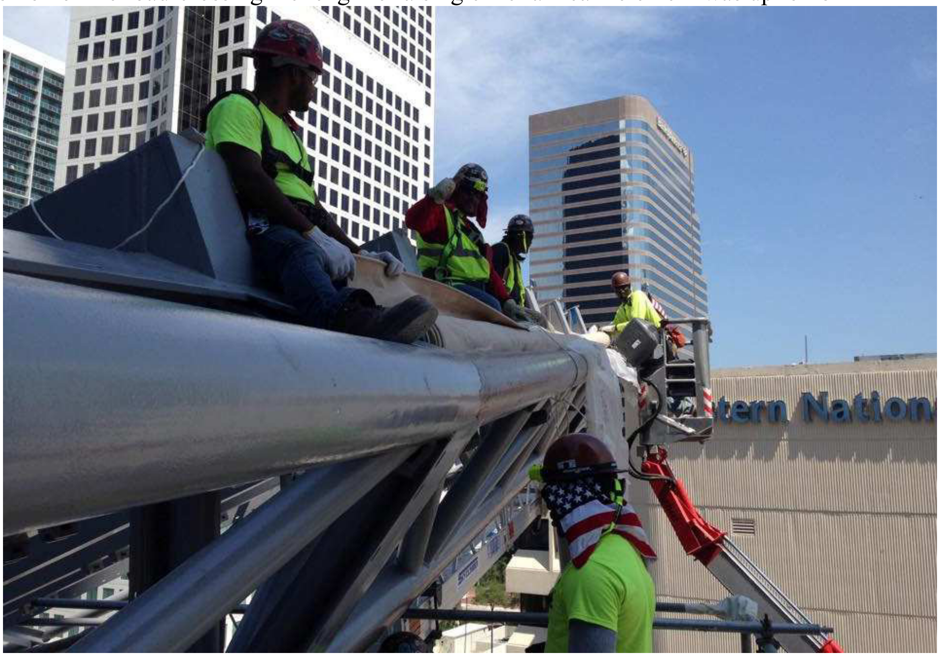

Fig. 13. Delta beam installation

Fig. 14. Long Delta Beam panel

Fig. 15. Aerial view of the final project

8. Conclusion

Based on wind and light simulations the architect developed the continuous geometry of membrane cladded strips under the glazing roof and along the perimeter, which is creating a comfortable place where people enjoy to stay. With the choice of long membrane panels and hidden details, the architect's intent was perfectly achieved. The complexity of the steel structure can only been seen on the second view. This was a big challenge for membrane engineering and fabrication. Using the similarity of the different panels together with parametric design tools was a great help to finalise the engineering of almost 400 different membrane panels.

Acknowledgements

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Architects: Arquitectonica, Miami, Florida
Climate Ribbon Designer: Hugh Dutton Associés, Paris
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Climate Ribbon Design Build Contractor: Josef Gartner, Würzburg, Germany
Fabric engineering: formTL Radolfzell, Germany
Fabric supplier: Verseidag Indutex, Germany
Fabric Manufacturer: Canobbio Textile Engineering, Italy

Surface Area Blades approx. 11100 m²
Surface Area Delta Beams approx. 2930 m²

Pictures

Fig. 1, 2a, 2b, 3, 4, 5, 6, 7, 8, 9, 11, 12a, 12b, 14, 15 form TL
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